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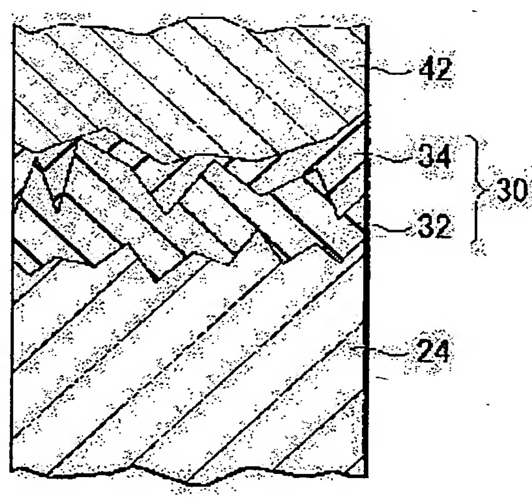
(54) MAGNETIC TUNNEL JUNCTION ELEMENT AND ITS MANUFACTURING METHOD AS WELL AS MAGNETIC HEAD JUNCTION TYPE HEAD AND ITS MANUFACTURING METHOD

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an MTJ element capable of obtaining a high TMR and a low resistance even at an ambient temperature and excellent symmetry of electric characteristics and an MTJ head as well as methods for manufacturing the same.
SOLUTION: The method for manufacturing the MTJ element 70 comprises the steps of sequentially laminating a first ferromagnetic layer 24, a tunnel barrier layer 30 and a second ferromagnetic layer 42. The tunnel barrier layer 30 is formed by the method comprising a step of forming a metal layer or a nonmagnetic layer on the first ferromagnetic layer 24 and oxidizing to form a first thin film 32, and a step of forming a second thin film 34 on the first thin film 32.



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CLAIMS

[Claim(s)]
[Claim 1] It is the magnetic tunnel junction component which is a magnetic tunnel junction component for detecting the impressed magnetic field, is pinched by the 1st ferromagnetic layer, the 2nd ferromagnetic layer, and said 1st and 2nd ferromagnetic layers, is equipped with the tunnel barrier layer which touches these two layers, and is characterized by said tunnel barrier layer containing the 1st barrier layer to which oxidation treatment was given, and the 2nd barrier layer.
[Claim 2] Said 2nd barrier layer is a magnetic tunnel junction component according to claim 1 characterized by performing oxidation treatment.
[Claim 3] Said 1st barrier layer is a magnetic tunnel junction component according to claim 1 characterized by having the thickness more than the thickness of said 2nd barrier layer.
[Claim 4] Furthermore, the magnetic tunnel junction component according to claim 1 characterized by having other at least one-layer barrier layers on said 2nd barrier layer.
[Claim 5] Said 1st barrier layer is a magnetic tunnel junction component according to claim 4 characterized by being thicker than any of a barrier layer besides the above, or being equivalent.
[Claim 6] Said 1st ferromagnetic layer is a magnetic tunnel junction component according to claim 1 characterized by being the ferromagnetic free layer from which the magnetization direction changes with external magnetic fields freely.
[Claim 7] The thickness of said 1st barrier layer is a magnetic tunnel junction component according to claim 1 characterized by being 0.6nm or less.
[Claim 8] At least one side among said 1st and 2nd barrier layers Chromium (Cr), Molybdenum (Mo), a tantalum (Ta), niobium (Nb), copper (Cu), Platinum (Pt), palladium (Pd), boron (B), carbon (C), aluminum (aluminum), A tungsten (W), silicon (Si), titanium (Ti), vanadium (V), The magnetic tunnel junction component according to claim 1 characterized by including at least one sort in the group which consists of a ruthenium (Ru), a rhenium (Re), a zirconium (Zr), and a gallium (Ga).
[Claim 9] The magnetic tunnel junction component according to claim 1 to which at least one side is characterized by including at least one sort in the group which consists of aluminum (aluminum), a tantalum (Ta), nickel (nickel), titanium (Ti), a hafnium (Hf), magnesium (Mg), silicon (Si), a zirconium (Zr), and a gallium (Ga) among said 1st and 2nd barrier layers.
[Claim 10] Said 2nd barrier layer is the magnetic tunnel junction component of claim 1 characterized by carrying out annealing treatment.
[Claim 11] The thickness of said 2nd barrier layer is a magnetic tunnel junction component according to claim 1 characterized by being 0.4nm or less.
[Claim 12] The thickness of said tunnel barrier layer is a magnetic tunnel junction component according to claim 1 characterized by being 1.5nm or less.
[Claim 13] It sets, when the bias voltage of the range of 0 to 500mV is impressed, and said tunnel barrier layer is the resistance difference [abs(R+-R-)/] (R++R-) of forward bias voltage and negative bias voltage. Magnetic tunnel junction component according to claim 1 characterized by being less than 3%.
[Claim 14] The process which is the approach of manufacturing the magnetic tunnel junction component for detecting the impressed magnetic field, and forms the 1st ferromagnetic part, The process which forms a tunnel barrier part on said 1st ferromagnetic part, The process which forms the 2nd ferromagnetic part on said tunnel barrier part is included. The formation process of said tunnel barrier part The manufacture approach of the magnetic tunnel junction component characterized by forming the 1st barrier part on said 1st ferromagnetic part, and including the process to oxidize and the process which forms the 2nd barrier part on said 1st barrier part.
[Claim 15] Said tunnel barrier partial formation process is the manufacture approach of the magnetic tunnel junction component according to claim 14 characterized by including the process which carries out oxidation treatment after forming the 2nd barrier part on the 1st [after oxidation treatment] barrier part.
[Claim 16] Said tunnel barrier partial formation process is the manufacture approach of the magnetic tunnel junction component according to claim 15 characterized by including further the process which forms other barrier parts of at least one layer on the 2nd barrier part after forming said 2nd barrier part.
[Claim 17] Said 1st barrier part is the manufacture approach of the magnetic tunnel junction component according to claim 14 characterized by having the thickness more than the thickness of said 2nd barrier part.
[Claim 18] Said 1st barrier part is the manufacture approach of the magnetic tunnel junction component according

to claim 16 characterized by being thicker than any of said 2nd barrier part, and a barrier part besides the above, or being equivalent.
[Claim 19] Said 1st ferromagnetic part is the manufacture approach of the magnetic tunnel junction component according to claim 14 characterized by being a ferromagnetic free part.
[Claim 20] The thickness of said 1st barrier part is the manufacture approach of the magnetic tunnel junction component according to claim 14 characterized by being 0.6nm or less.
[Claim 21] At least one side among said 1st and 2nd barrier parts Chromium (Cr), Molybdenum (Mo), a tantalum (Ta), niobium (Nb), copper (Cu), Platinum (Pt), palladium (Pd), boron (B), carbon (C), aluminum (aluminum), A tungsten (W), silicon (Si), titanium (Ti), vanadium (V), The manufacture approach of the magnetic tunnel junction component according to claim 14 characterized by including at least one sort in the group which consists of a ruthenium (Ru), a rhenium (Re), a zirconium (Zr), and a gallium (Ga).
[Claim 22] The manufacture approach of a magnetic tunnel junction component according to claim 14 that at least one side is characterized by including at least one sort in aluminum (aluminum), tantalum (Ta), nickel (nickel), titanium (Ti), hafnium (Hf), magnesium (Mg), silicon (Si), zirconium (Zr), and gallium (Ga) kana **** among said 1st and 2nd barrier parts.
[Claim 23] The manufacture approach of a magnetic tunnel junction component according to claim 14 that thickness of said 2nd barrier part is characterized by being 0.4nm or less.
[Claim 24] The manufacture approach of a magnetic tunnel junction component according to claim 16 that thickness of the maximum upper layer of a barrier part besides the above is characterized by being 0.4nm or less.
[Claim 25] The thickness of said tunnel barrier part is the manufacture approach of the magnetic tunnel junction component according to claim 14 characterized by being 1.5nm or less.
[Claim 26] Furthermore, the manufacture approach of the magnetic tunnel junction component according to claim 14 characterized by including the process which heats said tunnel barrier part after forming said 2nd ferromagnetic part.
[Claim 27] The manufacture approach of the magnetic tunnel junction component according to claim 26 characterized by heat-treating at less than 300 degrees C at said heating process.
[Claim 28] Said 1st and 2nd ferromagnetic parts are the manufacture approaches of the magnetic tunnel junction component according to claim 14 characterized by including at least one sort in the group which consists of cobalt (Co), iron (Fe), and nickel (nickel).
[Claim 29] Furthermore, the manufacture approach of the magnetic tunnel junction component according to claim 14 characterized by including the process which forms an antiferromagnetism part so that either of said 1st and 2nd ferromagnetic parts may be adjoined.
[Claim 30] The magnetic tunnel junction component manufacture approach according to claim 14 characterized by including the process which forms the 1st ferromagnetic layer, a non-magnetic metal layer, and the 2nd ferromagnetic layer in order in the process which forms at least one side among said 1st and 2nd ferromagnetic parts.
[Claim 31] In the process which forms at least one side among said 1st and 2nd ferromagnetic parts The process which forms the 1st and 2nd ferromagnetic layers and the non-magnetic metal layer pinched among them is included. This process The step which forms one ferromagnetic layer among said 1st and 2nd ferromagnetic layers using the ingredient containing cobalt (Co), a cobalt (Co) alloy, and a ferronickel (NiFe) alloy so that a tunnel barrier part may be adjoined, Into a ferronickel (NiFe) alloy or a ferronickel alloy, chromium (Cr), A tantalum (Ta), molybdenum (Mo), The manufacture approach of the magnetic tunnel junction component according to claim 14 characterized by including the step which forms the ferromagnetic layer of another side among said 1st and 2nd ferromagnetic layers using the alloy which comes to add at least one sort in the group which consists of niobium (Nb) and a zirconium (Zr).
[Claim 32] Furthermore, the manufacture approach of the magnetic tunnel junction component according to claim 14 characterized by including the process which forms the seed layer which has at least one sort in the group which consists of a tantalum (Ta), chromium (Cr), titanium (Ti), a nickel chromium (NiCr) alloy, and a nickel ferrochrome (NiFeCr) alloy.
[Claim 33] Furthermore, the manufacture approach of the magnetic tunnel junction component according to claim 14 characterized by including the process which forms the 1st and 2nd electric lead layers containing at least one sort in the group which consists of copper (Cu), aluminum (aluminum), and a ferronickel (NiFe) alloy.
[Claim 34] said tunnel barrier part — resistance difference [abs(R+-R-)/] (R++R-) with bias voltage forward bias voltage and negative to the case of the range of 0 to 500mV in bias voltage The manufacture approach of the magnetic tunnel junction component according to claim 14 characterized by forming so that it may become less than 3%.
[Claim 35] The process which forms the 1st ferromagnetic part, and the process which forms a tunnel barrier part and the 2nd ferromagnetic part on said 1st ferromagnetic part at this order are included. The process which the formation process of said tunnel barrier part forms the 1st barrier part which has the thickness of 0.6nm or less on said 1st ferromagnetic part, and is oxidized, The manufacture approach of the magnetic tunnel junction component characterized by including the process which forms the 2nd barrier part which has the thickness of 0.4nm or less on said 1st barrier part.
[Claim 36] Said tunnel barrier partial formation process is the manufacture approach of the magnetic tunnel junction component according to claim 35 characterized by forming the 2nd barrier part which has the thickness of 0.4nm or less on the 1st [after oxidation treatment / said] barrier part, and including the process which carries out oxidation

treatment.

[Claim 37] The manufacture approach of a magnetic tunnel junction component according to claim 35 that at least one side is characterized by including at least one sort in the group which consists of aluminum (aluminum), a tantalum (Ta), nickel (nickel), titanium (Ti), a hafnium (Hf), magnesium (Mg), silicon (Si), a zirconium (Zr), and a gallium (Ga) among said 1st and 2nd barrier part.

[Claim 38] The manufacture approach of the magnetic tunnel junction component according to claim 35 characterized by including the process which carries out heat-treatment of less than 5 hours at the temperature of less than 300 degrees C after forming said 2nd ferromagnetic part.

[Claim 39] It is the magnetic tunnel junction mold head which detects the data magnetically recorded on the magnetic-recording medium using the magnetic tunnel junction component. The 1st ferromagnetic layer, It is the magnetic tunnel junction mold head which is equipped with the tunnel barrier layer which touches on said 1st ferromagnetic layer, and the 2nd ferromagnetic layer which touches on said tunnel barrier layer, and is characterized by said tunnel barrier layer containing the 1st barrier layer by which it was oxidized, and the 2nd barrier layer.

[Claim 40] The process which is the approach of manufacturing the magnetic tunnel junction mold head which detects the data magnetically recorded on the magnetic-recording medium using the magnetic tunnel junction component, and forms the 1st ferromagnetic part, The process which forms a tunnel barrier part and the 2nd ferromagnetic part on said 1st ferromagnetic part at this order is included. Said tunnel barrier partial formation process The manufacture approach of the magnetic tunnel junction mold head characterized by forming the 1st barrier part on said 1st ferromagnetic part, and including the process to oxidize and the process which forms the 2nd barrier part on the 1st [after oxidation treatment / said] barrier part.

[Claim 41] It is the approach of manufacturing the magnetic tunnel junction mold head which detects the data magnetically recorded on the magnetic-recording medium using the magnetic tunnel junction component. The 1st ferromagnetic part, The process which forms a tunnel barrier part and the 2nd ferromagnetic part in this order is included. The formation process of said tunnel barrier part The process which forms the 1st barrier part which has the thickness of 0.6nm or less on said 1st ferromagnetic part, and is oxidized, The manufacture approach of the magnetic tunnel junction mold head characterized by including the process which forms the 2nd barrier part which has the thickness of 0.4nm or less on the 1st [after oxidation treatment / said] barrier part.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the magnetic tunnel junction component which has the tunnel barrier layer which is excellent in homogeneity and symmetry especially, its manufacture approach, a magnetic tunnel junction mold head equipped with the magnetic tunnel junction component, and its manufacture approach about the magnetic tunnel junction (magnetic tunnel junction:MTJ) component which detects the data magnetically recorded on the magnetic-recording medium, its manufacture approach, a magnetic tunnel junction mold head equipped with the magnetic tunnel junction component, and its manufacture approach.
[0002]
[Description of the Prior Art] the former -- anisotropy magnetic reluctance (Anisotropic Magneto-Resistance, following, AMR) -- effective -- it is -- the magnetic-reluctance (Magneto-Resistive, following, MR) component based on the spin bulb (Spin-Valve, following, SV) effectiveness is widely used as a playback transducer (transducer) for reproducing a magnetic-recording medium. Such a MR component detects the leakage field produced by change of the signal recorded on the record medium using resistance change produced in the reproducing-head section which consists of a magnetic material. Magnetic-reluctance rate-of-change deltaR/R using the AMR effectiveness of MR component (namely, AMR component) is low, and, generally is about 1 - 3%. On the other hand, generally deltaR/R of SV component at the time of impressing the same magnetic field reaches to 2 - 7%. The reproducing head using such a high sensitivity SV component can respond to very high recording density, and the recording density becomes several gigabits or more (several Gbits/in2 above, 1 Gbits/in2 **6.45 Gbits/cm2) per 1 square inch. Therefore, it came to replace SV mold reproducing head with the AMR reproducing head gradually.
[0003] Fundamental SV component has the structure where two ferromagnetic layers are separated by the non-magnetic layer as indicated by U.S. Pat. No. 5,159,513. Furthermore, with this SV component, the switched connection layer (pinning layer) formed with the iron manganese (FeMn) alloy is formed so that one of two ferromagnetic layers may be adjoined. between the ferromagnetic layers which adjoin a switched connection layer and this -- switched connection -- being generated -- the one direction of specification [the magnetization direction of the ferromagnetic layer] -- strong -- pinning -- that is, it is fixed. The ferromagnetic layer to which this magnetization direction was fixed is called a strong magnetic pinned layer. The magnetization direction of the ferromagnetic layer of another side, i.e., a ferromagnetic free layer, is freely rotated according to a small external magnetic field. With such an SV component, electric resistance increases and thereby comparatively high resistance rate of change (MR ratio) is obtained as the magnetization direction of two ferromagnetic layers changes from parallel to an anti-parallel condition.
[0004] As a MR component of a different type from the above-mentioned AMR component and above-mentioned SV component, there is a component using a tunnel magneto-resistive effect (Tunneling Magneto-Resistance, TMR). This is indicated by "the tunnel effect between ferromagnetic thin films" (225 "Tunneling Between Ferromagnetic Films", Physics Letters, 54A 1975) by Julliere. MR component using such TMR is known as a magnetic tunnel junction (Magnetic Tunnel Junction, MTJ) component or a magnetic-reluctance tunnel junction (Magneto-Resistive Tunnel Junction, MRTJ) component. The MTJ component as well as SV component has the structure which put the thin insulating layer by two ferromagnetic layers (electrode layer). One ferromagnetic layer is a strong magnetic pinned layer which has the magnetic moment fixed in the specific direction between two ferromagnetic layers, and another ferromagnetic layer is a ferromagnetic free layer (called a sense layer) which has the magnetic moment freely rotated according to an external magnetic field. Unlike SV component, actuation of a MTJ component is called a CPP (current perpendicular to the plane) mold. That is, the sense current which flows a MTJ component flows perpendicularly to the thickness direction, i.e., the membrane formation side, of a cascade screen. This sense current is produced by impressing bias voltage to two ferromagnetic layers of a MTJ component. This sense current is acquired because an electron passes a tunnel barrier layer according to the tunnel effect. For this reason, as for the tunnel barrier layer, electron tunneling has become thinly enough so that may be obtained.
[0005] It depends for the process in which an electron passes an insulating layer in the spin polarization condition strongly. Namely, the sense current which flows a MTJ component is influenced in the spin polarization condition of two ferromagnetic layers (a strong magnetic pinned layer and ferromagnetic free layer), and the relative direction of the magnetic moment (the magnetization direction). Since two ferromagnetic layers show a different reaction to an external magnetic field, they can change the relative magnetization direction in these two ferromagnetic layers

according to an external magnetic field.

[0006] A sense current's passage of the 1st ferromagnetic layer spin-polarization-izes an electron. the magnetization direction of two ferromagnetic layers -- mutual -- anti- -- the probability for electron tunneling which minded the tunnel barrier layer when **** to be obtained -- falling -- consequently, a sense current -- flowing -- being hard -- the big bond resistance Rap is obtained. On the other hand, since the probability for electron tunneling to be obtained becomes high and a sense current becomes easy to flow when the magnetization direction of two ferromagnetic layers is mutually parallel, thereby, it is the small bond resistance Rp. It is obtained. the magnetization direction of both ferromagnetic layers -- mutual -- the middle condition of a condition [****], i.e., an parallel condition and an anti-parallel condition, -- bond resistance Rm Rap and Rp middle magnitude -- becoming -- Rap>Rm >Rp ** -- the relation to say is obtained. If magnetic-reluctance rate of change (TMR ratio) is defined using these notations, it is deltaR/R= (Rap-Rp)/Rp. It can express.

[0007] Like the magnetization transition in a magnetic-recording medium, arrangement of the relative magnetization direction of two ferromagnetic layers, i.e., an include angle, is influenced in an external magnetic field, and it changes. Since this relative include-angle change of the magnetization direction also influences the electric resistance of a MTJ component, output voltage changes. Therefore, it becomes possible by detecting the change of output voltage based on change of electric resistance, i.e., include-angle change of the relative magnetization direction, to detect change of an external magnetic field. Thus, a MTJ component can reproduce now information recorded on the magnetic-recording medium.

[0008]

[Problem(s) to be Solved by the Invention] The MTJ component reported before 1995 had only the low thing of the TMR effectiveness, and the TMR ratio under a room temperature was about about 1 - 2%. However, after the MTJ component which will show 10% or more of high TMR ratio for the first time under a room temperature in 1995 was discovered, expectation that a MTJ component was applicable to playback of a super-high density record medium grew. this -- being related -- Moodera ** -- it was reported by the "ferromagnetic thin film tunnel junction which has big magnetic reluctance under a room temperature" ("Large Magnetoresistance at Room Temperature in Ferromagnetic Thin Film tunnel Junctions", Physics.Review.Letters, 74, 327, 1995) to depend.

[0009] However, it was difficult the former to make the MTJ component suitable for practical use which shows high TMR ratio sufficient in the bottom of a room temperature. The main factors which obstruct application to the reproducing head are the points that junction resistance is large and a signal-to-noise (Signal to Noise, S/N) ratio falls with the conventional MTJ component. In order to raise surface recording density, contraction of the plane-of-composition product in a MTJ component is not avoided, but the factor of big junction resistance poses a serious problem inevitably. On the other hand, by "Magnetic Tunnel Junctions WithIn Situ Naturally-Oxidized Tunnel Barrier" (magnetic tunnel junction which has the tunnel barrier by the natural oxidation method) (Appl.Phys.Lett.71, 3296 (1997)) by Tsuge and Mitsuzuka, if a resistance junction value is low, the phenomenon in which a TMR ratio becomes small is reported.

[0010] As a problem produced with a MTJ component, there is a thing called a shot noise (noise produced in case an electron passes a tunnel barrier layer), and this leads to the fall of a S/N ratio. A shot noise is proportional to the junction resistance R and the square root of the sense current I. In detail, it is shown in the following (1) type. Here, Vrms and a frequency band are set to deltaf for a shot noise. In addition, among (1) type, e is quantum of electricity and is abbreviation 1.6x10-19 C (coulomb).

[0011]

Vrms =(2ande-I-deltaf) 0.5 and R ... (1)

[0012] In order to obtain a S/N ratio high enough, it is necessary to reduce the junction resistance R. As this bond resistance R was shown in (2) types, it turns out that it changes exponentially to the square root of thickness d of a tunnel barrier layer, and obstruction height (energy gap) phi of a tunnel barrier layer.

[0013]

R**exp (d-phi 1/2) ... (2)

[0014] (2) As shown in a formula, it is possible by making thickness d thin to reduce the junction resistance R. However, if the thickness of a tunnel barrier layer decreases, a new problem may arise or the effect may increase. For example, when the thickness of a tunnel barrier layer is too thin, a pinhole will occur. This pinhole makes a tunnel barrier layer generate leakage current, and causes the problem of decreasing junction resistance and a S/N ratio.

[0015] Furthermore, the problem [d / of a tunnel barrier layer / thickness] of being uneven also exists in the conventional MTJ component. On the oxide front face which is a top face of the tunnel barrier layer after oxidization, oxygen is mostly distributed rather than the base. For this reason, when bias voltage is impressed, an electrical property (for example, output voltage) shows asymmetry (asymmetry). Such asymmetry makes obstruction height (energy gap) phi of the direction which intersects perpendicularly with thickness d of a tunnel barrier layer change.

[0016] As a problem relevant to a MTJ component, an electrostatic discharge (Electro Static Discharge, ESD) is mentioned. There is breakdown voltage in a MTJ component and it is usually about 150 volts (V). When the MTJ component has a showing [asymmetry] electrical property, the breakdown voltage of one direction of bias becomes lower than the direction of bias of another side. Therefore, since the breakdown voltage of a MTJ component becomes lower than the case where there is no asymmetry, by ESD, it leads to destruction of a MTJ component.

[0017] As other problems relevant to a MTJ component, the time dependency (Time Dependence of Dielectric

Breakdown, TDDB) of dielectric breakdown is mentioned. Resistance of a tunnel barrier layer (namely, dielectric) will decrease with the passage of time for it not to be desirable. In this case, if the tunnel barrier layer is more homogeneous, the more the symmetry of the electrical property of a tunnel barrier layer is more excellent a certain forge fire, the more a tunnel barrier layer will be stabilized more with time.
[0018] Furthermore, there is a problem whether rate of an excellent article sufficient at the time of mass production method of a MTJ component is secured as another problem relevant to a MTJ component. Usually, many MTJ components are formed on one wafer. Unless it is fixed in the direction in which the width of face, the thickness, or the obstruction height of a tunnel barrier layer crosses a wafer, many of produced MTJ components become inadequate [output voltage or performance characteristics like a bond resistance], and it does not meet Quality Control Standard Code. Therefore, in order to raise the ratio of the product to the rate of an excellent article, i.e., the total volume, of a MTJ component, a tunnel barrier layer is homogeneous and it is required for the electrical property to have symmetric property.
[0019] This invention was made in view of this trouble, it shows high tunnel magnetic-reluctance rate of change, and the purpose is to provide the bottom of a room temperature with the magnetic tunnel junction component applicable to playback, its manufacture approach, the magnetic tunnel junction mold head, and its manufacture approach of a high density record medium while showing low junction resistance.
[0020] The 2nd purpose of this invention is offering the magnetic tunnel junction component equipped with the tunnel barrier layer which has the electrical property which is excellent in symmetry, its manufacture approach, a magnetic tunnel junction mold head, and its manufacture approach.
[0021] The 3rd purpose of this invention is offering a magnetic tunnel junction component excellent in ESD and TDDB, its manufacture approach, a magnetic tunnel junction mold head, and its manufacture approach.
[0022] Furthermore, the 4th purpose of this invention is to offer the magnetic tunnel junction component which has the homogeneous tunnel barrier layer which can maintain the high rate of an excellent article at the time of mass production method, its manufacture approach, a magnetic tunnel junction mold head, and its manufacture approach.
[0023]
[Means for Solving the Problem] The magnetic tunnel junction component of this invention is a magnetic tunnel junction component for detecting the impressed magnetic field. The 1st ferromagnetic layer, It is inserted into the 2nd ferromagnetic layer, and these [1st] and the 2nd ferromagnetic layer, and it has the tunnel barrier layer which is in contact with these two layers, and is made for this tunnel barrier layer to contain the 1st barrier layer to which oxidation treatment was given, and the 2nd barrier layer.
[0024] With the magnetic tunnel junction component of this invention, since the tunnel barrier layer contains the 1st barrier layer by which it was oxidized, and the 2nd barrier layer, the tunnel barrier layer which has uniform insulation according to the thickness direction can be formed.
[0025] It is desirable that oxidation treatment is performed to the 2nd barrier layer with the magnetic tunnel junction component of this invention.
[0026] As for the 1st barrier layer, with the magnetic tunnel junction component of this invention, it is desirable to have the thickness more than the thickness of the 2nd barrier layer. By this, the tunnel barrier layer which has more uniform insulation can be formed.
[0027] Furthermore, it is desirable to have other at least one-layer barrier layers on the 2nd barrier layer further with the magnetic tunnel junction component of this invention.
[0028] With the magnetic tunnel junction component of this invention, the thickness of the 1st barrier layer is thicker than any of other barrier layers, or its equivalent thing is desirable.
[0029] It is desirable for the 1st ferromagnetic layer to be a ferromagnetic free layer from which the magnetization direction changes with external magnetic fields freely with the magnetic tunnel junction component of this invention.

[0030] As for the thickness of the 1st barrier layer, with the magnetic tunnel junction component of this invention, it is desirable that it is 0.6nm or less.
[0031] With the magnetic tunnel junction component of this invention, among the 1st and 2nd barrier layers, at least one side Chromium (Cr), molybdenum (Mo), a tantalum (Ta), niobium (Nb), Copper (Cu), platinum (Pt), palladium (Pd), boron (B), carbon (C), It is desirable that it is a thing containing at least one sort in the group which consists of aluminum (aluminum), a tungsten (W), silicon (Si), titanium (Ti), vanadium (V), a ruthenium (Ru), a rhenium (Re), a zirconium (Zr), and a gallium (Ga).
[0032] It is desirable for at least one side to be a thing containing at least one sort in the group which consists of aluminum (aluminum), a tantalum (Ta), nickel (nickel), titanium (Ti), a hafnium (Hf), magnesium (Mg), silicon (Si), a zirconium (Zr), and a gallium (Ga) among the 1st and 2nd barrier layers with the magnetic tunnel junction component of this invention.
[0033] With the magnetic tunnel junction component of this invention, annealing treatment of the 2nd barrier layer may be carried out.
[0034] As for the thickness of the 2nd barrier layer, with the magnetic tunnel junction component of this invention, it is desirable that it is 0.4nm or less.
[0035] As for the thickness of a tunnel barrier layer, with the magnetic tunnel junction component of this invention, it is desirable that it is 1.5nm or less.
[0036] the case where the bias voltage of the range of 0 to 500mV is impressed with the magnetic tunnel junction component of this invention — setting — resistance difference [abs(R+-R-)/] (R++R-) of the tunnel barrier layer of

forward bias voltage and negative bias voltage It is desirable that it is less than 3%.

[0037] The manufacture approach of the magnetic tunnel junction component of this invention The process which is the approach of manufacturing the magnetic tunnel junction component for detecting the impressed magnetic field, and forms the 1st ferromagnetic part, The process which forms a tunnel barrier part and the 2nd ferromagnetic part in order on this 1st ferromagnetic part is included. The formation process of a tunnel barrier part The 1st barrier part is formed on the 1st ferromagnetic part, and it is made to include the process to oxidize and the process which forms the 2nd barrier part on this 1st barrier part.

[0038] By the manufacture approach of the magnetic tunnel junction component of this invention, since the 1st barrier part is formed and it was made to include the process to oxidize and the process which forms the 2nd barrier part on this 1st barrier part, the tunnel barrier part which has uniform insulation according to the thickness direction can be formed.

[0039] After forming the 2nd barrier part on the 1st [after oxidation treatment] barrier part, you may make it include the process which carries out oxidation treatment by the manufacture approach of the magnetic tunnel junction component of this invention. In this case, the tunnel barrier part which has uniform insulation according to the thickness direction further can be formed.

[0040] After forming the 2nd barrier part, you may make it include further the process which forms other barrier parts of at least one layer on the 2nd barrier part in a tunnel barrier partial formation process by the manufacture approach of the magnetic tunnel junction component of this invention.

[0041] As for the 1st barrier part, by the manufacture approach of the magnetic tunnel junction component of this invention, it is desirable to have the thickness more than the thickness of the 2nd barrier part.

[0042] By the manufacture approach of the magnetic tunnel junction component of this invention, the 1st barrier part is thicker than any of the 2nd barrier part and other barrier parts, or its equivalent thing is desirable.

[0043] By the manufacture approach of the magnetic tunnel junction component of this invention, the 1st ferromagnetic part may be a ferromagnetic free part.

[0044] As for the thickness of the 1st barrier part, by the manufacture approach of the magnetic tunnel junction component of this invention, it is desirable that it is 0.6nm or less.

[0045] By the manufacture approach of the magnetic tunnel junction component of this invention At least one side among the 1st and 2nd barrier parts Chromium (Cr), Molybdenum (Mo), a tantalum (Ta), niobium (Nb), copper (Cu), Platinum (Pt), palladium (Pd), boron (B), carbon (C), aluminum (aluminum), It is desirable to include at least one sort in the group which consists of a tungsten (W), silicon (Si), titanium (Ti), vanadium (V), a ruthenium (Ru), a rhenium (Re), a zirconium (Zr), and a gallium (Ga).

[0046] It is desirable for at least one side to contain at least one sort in the group which consists of aluminum (aluminum), a tantalum (Ta), nickel (nickel), titanium (Ti), a hafnium (Hf), magnesium (Mg), silicon (Si), a zirconium (Zr), and a gallium (Ga) among the 1st and 2nd barrier parts by the manufacture approach of the magnetic tunnel junction component of this invention.

[0047] It is desirable for the thickness of the 2nd barrier part to be 0.4nm or less by the manufacture approach of the magnetic tunnel junction component of this invention.

[0048] It is desirable for the thickness of the maximum upper layer of other barrier parts to be 0.4nm or less by the manufacture approach of the magnetic tunnel junction component of this invention.

[0049] As for the thickness of a tunnel barrier part, by the manufacture approach of the magnetic tunnel junction component of this invention, it is desirable that it is 1.5nm or less.

[0050] After forming the 2nd ferromagnetic part by the manufacture approach of the magnetic tunnel junction component of this invention, it is desirable to include the process which heats said tunnel barrier part.

[0051] As for a heating process, by the manufacture approach of the magnetic tunnel junction component of this invention, it is desirable to heat-treat at less than 300 degrees C.

[0052] As for the 1st and 2nd ferromagnetic parts, by the manufacture approach of the magnetic tunnel junction component of this invention, it is desirable to include at least one sort in the group which consists of cobalt (Co), iron (Fe), and nickel (nickel).

[0053] It is desirable to include the process which forms an antiferromagnetism part further by the manufacture approach of the magnetic tunnel junction component of this invention so that either of the 1st and 2nd ferromagnetic parts may be adjoined.

[0054] It is desirable to include the process which forms the 1st ferromagnetic layer, a non-magnetic metal layer, and the 2nd ferromagnetic layer in order by the manufacture approach of the magnetic tunnel junction component of this invention in the process which forms at least one side among the 1st and 2nd ferromagnetic parts.

[0055] By the manufacture approach of the magnetic tunnel junction component of this invention In the process which forms at least one side among the 1st and 2nd ferromagnetic parts The process which forms the 1st and 2nd ferromagnetic layers and the non-magnetic metal layer pinched among them is included. This process The step which forms a ferromagnetic layer using the ingredient containing cobalt (Co), a cobalt (Co) alloy, and a ferronickel (NiFe) alloy so that a tunnel barrier layer may be adjoined, Into a ferronickel (NiFe) alloy or a ferronickel alloy, chromium (Cr), It is desirable to include the step which forms other ferromagnetic layers using the alloy which comes to add at least one sort in the group which consists of a tantalum (Ta), molybdenum (Mo), niobium (Nb), and a zirconium (Zr).

[0056] It is desirable to include the process which forms the seed layer which has at least one sort in the group which consists of a tantalum (Ta), chromium (Cr), titanium (Ti), a nickel chromium (NiCr) alloy, and a nickel

ferrochrome (NiFeCr) alloy by the manufacture approach of the magnetic tunnel junction component of this invention.

[0057] It is desirable to include the process which forms the 1st and 2nd electric lead layers which contain at least one sort in the group which consists of copper (Cu), aluminum (aluminum), and a ferronickel (NiFe) alloy by the manufacture approach of the magnetic tunnel junction component of this invention.

[0058] the manufacture approach of the magnetic tunnel junction component of this invention — a tunnel barrier part — resistance difference [abs(R+−R−)/] (R++R−) with bias voltage forward bias voltage and negative to the case of the range of 0 to 500mV in bias voltage It is desirable to form so that it may become less than 3%.

[0059] The manufacture approach of the magnetic tunnel junction component of this invention The process which forms the 1st ferromagnetic part, and the process which forms a tunnel barrier part and the 2nd ferromagnetic part on this 1st ferromagnetic part at this order are included. The formation process of a tunnel barrier part forms the 1st barrier part which has the thickness of 0.6nm or less on the 1st ferromagnetic part, and it is made to include the process to oxidize and the process which forms the 2nd barrier part which has the thickness of 0.4nm or less on this 1st barrier part.

[0060] By the manufacture approach of the magnetic tunnel junction component of this invention, since the 1st barrier part is formed and it was made to include the process to oxidize and the process which forms the 2nd barrier part on this 1st barrier part, the tunnel barrier part which has uniform insulation according to the thickness direction can be formed.

[0061] It is desirable to form the 2nd barrier part to which the formation process of a tunnel barrier part has the thickness of 0.4nm or less on the 1st [after oxidation treatment] barrier part by the manufacture approach of the magnetic tunnel junction component of this invention, and to include the process which carries out oxidation treatment.

[0062] It is desirable for at least one side to contain at least one sort in the group which consists of aluminum (aluminum), a tantalum (Ta), nickel (nickel), titanium (Ti), a hafnium (Hf), magnesium (Mg), silicon (Si), a zirconium (Zr), and a gallium (Ga) among the 1st and 2nd barrier part by the manufacture approach of the magnetic tunnel junction component of this invention.

[0063] After forming the 2nd ferromagnetic part by the manufacture approach of the magnetic tunnel junction component of this invention, it is desirable to include the process which carries out heat-treatment of less than 5 hours at the temperature of less than 300 degrees C.

[0064] The magnetic tunnel junction mold head of this invention is a magnetic tunnel junction mold head which detects the data magnetically recorded on the magnetic-recording medium using the magnetic tunnel junction component. The 1st ferromagnetic layer, It has the structure where the laminating of a tunnel barrier layer and the 2nd ferromagnetic layer was carried out to order, and is made for a tunnel barrier layer to contain the 1st barrier layer by which it was oxidized, and the 2nd barrier layer.

[0065] With the magnetic tunnel junction mold head of this invention, since the tunnel barrier layer contains the 1st barrier layer by which it was oxidized, and the 2nd barrier layer, the tunnel barrier layer which has uniform insulation according to the thickness direction can be formed.

[0066] The manufacture approach of the magnetic tunnel junction mold head of this invention The process which is the approach of manufacturing the magnetic tunnel junction mold head which detects the data magnetically recorded on the magnetic-recording medium using the magnetic tunnel junction component, and forms the 1st ferromagnetic part, The process which forms a tunnel barrier part and the 2nd ferromagnetic part on the 1st ferromagnetic part at this order is included. The formation process of a tunnel barrier part The 1st barrier part is formed on the 1st ferromagnetic part, and it is made to include the process to oxidize and the process which forms the 2nd barrier part on the 1st [after oxidation treatment] barrier part.

[0067] The manufacture approach of the magnetic tunnel junction mold head of this invention The process which is the approach of manufacturing the magnetic tunnel junction mold head which detects the data magnetically recorded on the magnetic-recording medium using the magnetic tunnel junction component, and forms the 1st ferromagnetic part, The process which forms a tunnel barrier part and the 2nd ferromagnetic part on this 1st ferromagnetic part at this order is included. The formation process of a tunnel barrier part It is made to include the process which forms the 1st barrier part which has the thickness of 0.6nm or less on the 1st ferromagnetic part, and forms the 2nd barrier part which has the thickness of 0.4nm or less on the process to oxidize and the 1st [after oxidation treatment] barrier part.

[0068] By the manufacture approach of the magnetic tunnel junction mold head of this invention, in a tunnel barrier partial formation process, the 1st barrier part is formed, and since it was made to include the process to oxidize and the process which forms the 2nd barrier part on the 1st [after oxidation treatment] barrier part, the tunnel barrier layer which has uniform insulation according to the thickness direction can be formed.

[0069]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained with reference to a drawing.

[0070] [The gestalt of the 1st operation]

<the configuration of a MTJ component and a MTJ head> — the configuration of the magnetic tunnel junction mold (MTJ) head which contains the magnetic tunnel junction (MTJ) component concerning the gestalt of operation of this invention and this MTJ component with reference to drawing 1 and drawing 2 first is explained collectively.

[0071] Drawing 1 is the top view of the MTJ head 1 containing the MTJ component 70 concerning the gestalt of this

operation. Drawing 2 is the fragmentary sectional view of the MTJ head 1 containing the MTJ component 70 of drawing 1 .

[0072] The MTJ head 1 has the structure where the laminating of the lower electrical-and-electric-equipment lead layer 10, the MTJ component 70, an insulating layer 50, and the up electrical-and-electric-equipment lead layer 60 was carried out to order, on the substrate 9. Here, the MTJ component 70 was laid under the insulating layer 50, the lower front face of the TMR component 70 touched the lower electrical-and-electric-equipment lead layer 10, and, on the other hand, the up front face is in contact with the up electrical-and-electric-equipment lead layer 60. The lower electrical-and-electric-equipment lead layer 10 and the up electrical-and-electric-equipment lead layer 60 achieve the function as a current path to pass a sense current in the direction perpendicular to a laminating side, to the MTJ component 70. An insulating layer 50 is for insulating electrically the lower electrical-and-electric-equipment lead layer 10 and the up electrical-and-electric-equipment lead layer 60.

[0073] The MTJ component 70 by the gestalt of this operation is for reading the information written in the magnetic-recording medium which does not demonstrate and illustrate a tunnel magneto-resistive effect, and has a laminated structure as shown in drawing 2 . The lower electrical-and-electric-equipment lead layer 10 is touched, the lower electrode layered product 20 is formed, and the laminating of the tunnel barrier layer 30 and the up electrode layered product 40 is carried out to order on it. Both the lower electrode layered products 20 and up electrode layered products 40 that adjoin each other on both sides of the tunnel barrier layer 30 contain the ferromagnetic layer. As shown in drawing 2 , the lower electrode layered product 20 formed on the up front face of the lower electrical-and-electric-equipment lead 10 contains the seed layer 22 and the ferromagnetic free layer 24 formed on the seed layer 22. The seed layer 22 is a non-magnetic layer, and raises the magnetic properties of the ferromagnetic free layer 24, and crystallinity.

[0074] The up electrode layered product 40 has the structure where the strong magnetic pinned layer 42, the antiferromagnetism layer (called a switched connection layer) 44, and the protective layer 46 were formed in order. A strong magnetic pinned layer 42 is also called the fixed bed. Even if, as for this, the external magnetic field of a certain direction is impressed to a MTJ component, it is because rotation of the magnetic moment in a strong magnetic pinned layer 42 is barred by the antiferromagnetism layer 44 and the magnetization direction is being fixed. Also where the magnetic moment of the ferromagnetic free layer 24 was not fixed, therefore a magnetic field is impressed in the predetermined range on the other hand, the magnetic moment can be rotated freely. Here, as for the magnetization direction 43 of a strong magnetic pinned layer 42, it is desirable to double in parallel to an external magnetic field. The magnetization direction 23 of the ferromagnetic free layer 24 is in a condition without an external magnetic field, and it is desirable to be perpendicularly located to the magnetization direction 43 of a strong magnetic pinned layer 42.

[0075] A sense current flows toward the lower electrical-and-electric-equipment lead layer 10 from the up electrical-and-electric-equipment lead layer 60. Therefore, it passes perpendicularly to a laminating side in order of a protective layer 46, the antiferromagnetism layer 44, a strong magnetic pinned layer 42, the tunnel barrier layer 30, the ferromagnetic free layer 24, the seed layer 22, and the lower electrical-and-electric-equipment lead layer 10. The amount of the flowing tunnel current depends for the tunnel barrier layer 30 in the magnetization direction of the magnetization direction 23 of the ferromagnetic free layer 24, and the magnetization direction 43 of a strong magnetic pinned layer 42 of two ferromagnetic layers which are separated by the tunnel barrier layer 30 and adjoin it, i.e., the relative direction. Thus, the current path is formed in the lower electrical-and-electric-equipment lead layer 10 from the top electrical-and-electric-equipment lead 60 at the MTJ component.

[0076] By the magnetic field from a magnetic-recording medium, the magnetization direction 23 is rotated so that it may become parallel or anti-parallel in the magnetization direction 43. By this, the relative orientation of the magnetic moment of two ferromagnetic layers 24, i.e., a ferromagnetic free layer, and a strong magnetic pinned layer 42 changes, and the amount of tunnel current also changes further. Therefore, the junction resistance of the MTJ component 70 changes, and this resistance change is detected as output voltage change, and is changed into playback data by for example, the magnetic-disk driving gear (not shown).

[0077] Drawing 3 is the sectional view of MTJ head 1' showing the modification of the MTJ component in the gestalt of the 1st operation shown in drawing 2 . This MTJ component is equipped with strong magnetic pinned layer 42' below tunnel barrier layer 30'. "'" was substantially attached and displayed on the same component as the component of the gestalt of the 1st operation shown in drawing 1 at the same sign. It is the description that the template layer 25 is formed [which was shown in drawing 2] between seed layer 22' and antiferromagnetism layer (pinning layer) 44' in addition to the component of the gestalt of the 1st operation. Ferromagnetic free layer 24' is one example of "the 2nd ferromagnetic layer" of this invention, and strong magnetic pinned layer 42' is one example of "the 1st ferromagnetic layer" of this invention.

[0078] The <manufacture approach of a MTJ head>, next the above-mentioned manufacture approach of a magnetic tunnel junction mold (MTJ) head are explained. In addition, the manufacture approach of the magnetic tunnel junction (MTJ) component concerning the gestalt of this operation is also explained collectively.

[0079] With reference to drawing 1 , drawing 2 , and drawing 4 , the manufacture approach of the MTJ head 1 and the MTJ component 70 is explained. Drawing 4 is the sectional view having expanded and shown each class of MTJ70.

[0080] First, after forming the insulating layer (not shown) which consists of an alumina etc. by sputtering etc. on a base 9, the lower electrical-and-electric-equipment lead layer 10 which consists of structure which carried out the laminating of the structure which carried out the laminating of two or more conductive non-magnetic materials, for

example, a tantalum, (Ta), copper (Cu), and the tantalum to order is formed on this insulating layer. Next, while forming the TMR component 70 in the part on the lower electrical-and-electric-equipment lead layer 10, as the perimeter field of the TMR component 70 is embedded, the insulating layers 50, such as an alumina (aluminum 2O3), are formed on the lower electrical-and-electric-equipment lead layer 10. The up electrical-and-electric-equipment lead layer 60 which consists of structure which carried out the laminating of a tantalum, copper, and the tantalum to order is formed by sputtering etc. so that the TMR component 70 and an insulating layer 50 may be covered after this.
[0081] Formation of the MTJ head equipped with the current path (the lower electrical-and-electric-equipment lead layer 10 and up electrical-and-electric-equipment lead layer 60) for passing a sense current in the direction perpendicular to a laminating side by the above to the TMR component 70 using a tunnel magneto-resistive effect and the TMR component 70 for magnetic-recording medium playback is completed.
[0082] Here, the TMR component 70 is formed as follows, for example. As shown in drawing 2 , the seed layer 22 is formed by sputtering etc. on the lower electrode lead layer 10. As for the seed layer 22, it is desirable to be formed with the ingredient chosen from the group which consists of a tantalum, chromium (Cr), titanium (Ti), a nickel chromium (NiCr) alloy, and a nickel ferrochrome (NiCrFe) alloy. On the seed layer 22, the ferromagnetic free layer 24 which consists of a ferromagnetic layer is formed by sputtering etc. The ferromagnetic free layer 24 In this case, for example, the 1st ferromagnetic containing the high ingredient of spin polarization nature, such as cobalt (Co), a cobalt alloy, and a ferronickel (NiFe) alloy, It is desirable that it is the structure of having the 2nd ferromagnetic containing the ingredient which are low magnetization, such as a ferronickel (NiFe) alloy and a NiFeX alloy (X= chromium (Cr), a tantalum (Ta), molybdenum (Mo), niobium (Nb), zirconium (Zr)), and low coercive force. Thus, the lower electrode layered product 20 is formed on the lower electrode lead layer 10.
[0083] Then, the tunnel barrier layer 30 is formed by forming a metal layer etc. by sputtering etc. on the lower electrode layered product 20, and oxidizing a metal layer for this for example, by the natural oxidation method (the so-called in situ law). The manufacture approach of the tunnel barrier layer 30 is explained in full detail behind.
[0084] After forming the tunnel barrier layer 30, the laminating of the magnetic layers, such as non-magnetic layers, such as magnetic layers, such as a CoFe alloy, and a ruthenium (Ru), and a CoFe alloy, is carried out to order, and a strong magnetic pinned layer 42 is formed. In addition, as for a strong magnetic pinned layer 42, it is desirable to have the structure in which two ferromagnetic layers are carrying out antiferromagnetism association on both sides of the non-magnetic metal layer chosen from the group which consists of others, a rhenium (Re), a rhodium (Rh), copper, chromium, etc. [ruthenium] Subsequently, the antiferromagnetism layer 44 which consists of a platinum manganese (PtMn) alloy etc. is too formed by sputtering etc. Switched connection arises in the interface of a strong magnetic pinned layer 42 and the antiferromagnetism layer 44, and the sense of the magnetization in a strong magnetic pinned layer 42 is fixed. Finally, the protective layer 46 which consists of a tantalum is formed on the antiferromagnetism layer 44. In this way, formation of the TMR component 70 is completed. In addition, the ferromagnetic free layer 24 is one example of "the 1st ferromagnetic layer" of this invention, and a strong magnetic pinned layer 42 is one example of "the 2nd ferromagnetic layer" of this invention.
[0085] And it is a modification in the gestalt of the 1st operation, the manufacture approach of MTJ component 70' is explained below with reference to drawing 3 and drawing 5 . Drawing 5 is the sectional view having expanded and shown each class of MTJ70'. Here, it omits [what / has the name same among the components of MTJ component 70' as the MTJ component 70] suitably about a concrete process and a name. In addition, since it is substantially [as the manufacture approach of the MTJ head 1] the same, the MTJ head 1' manufacture approach about components other than MTJ component 70' is omitted.
[0086] MTJ component 70' is formed as follows, for example. As shown in drawing 3 , seed layer 22' is formed by sputtering etc. on the lower electrode lead layer 10. On seed layer 22', the template layer 25 which consists of a tantalum, chromium, titanium, a NiCr alloy, or a NiCrFe alloy by sputtering etc. is formed. Furthermore, lower electrode layered product 20' by which the laminating of seed layer 22', the template layer 25, antiferromagnetism layer 44', and strong magnetic pinned layer 42' was carried out to order is formed by forming antiferromagnetism layer 44' and strong magnetic pinned layer 42' in order. Then, tunnel barrier layer 30' is formed on lower electrode layered product 20'. After forming tunnel barrier layer 30', up electrode layered product 40' is formed by forming ferromagnetic free layer 24' and protective layer 46'. In this way, MTJ component 70' completion of is done.
[0087] In order to raise the TMR ratio of the oxidation style of a tunnel barrier layer, and the <evaluation> MTJ component 70 and to also improve a S/N ratio, especially the method of using the seed layer 22 and reducing the surface roughness of the lower electrode layered product 20 is desirable. Moreover, the tunnel barrier layer 30 carries out the laminating of the film formed with the aluminum film or other ingredients under low temperature, and can form it by oxidizing by the plasma. such junction resistance of the MTJ component 70 — the cross section — 200x300micrometer2 it is — a case — hundreds of ohms to several 10 — it becomes the range of K omega.
[0088] In order to improve the S/N ratio of the MTJ component 70, the thickness of the tunnel barrier layer 30 is reduced and how to lower junction resistance is also considered. At this time, the tunnel barrier layer 30 is formed by oxidizing the aluminum film. Instead of the aluminum film, or chromium, molybdenum, a tantalum, Niobium, copper, platinum (Pt), palladium (Pd), boron (B), carbon (C), Aluminum, a tungsten (W), silicon (Si), titanium, vanadium (V), It is also possible to apply what oxidized the metal layer containing at least one of the groups which consist of a ruthenium, a rhenium, a zirconium, and a gallium (Ga), and the nonmetal layer to the tunnel barrier layer 30.
[0089] Drawing 6 is the fragmentary sectional view of the MTJ component 170 containing the tunnel barrier layer 130 of the monolayer formed by the conventional single oxidizing method. The laminating of the barrier 130 is

carried out on the ferromagnetic free layer 124, and the laminating of the strong magnetic pinned layer 142 is carried out further. As shown in drawing 6 , the thickness changes greatly with laminating plane field places, and the tunnel barrier layer's 130 obtained by the single oxidizing method is often quite uneven. Furthermore, whenever [distribution / of the oxygen in the thickness direction] differ greatly. Thus, with the MTJ component 170 which has the uneven tunnel barrier layer 130, the asymmetry (asymmetry) in electrical properties, such as relation between a sense current and bias voltage, becomes remarkable.

[0090] On the other hand, with the gestalt of operation of the 1st of this invention, as shown in drawing 7 , the laminating of two or more metal layers or nonmetal layers is carried out continuously, and the tunnel barrier layer 30 of the MTJ component 70 is formed by oxidizing. By this approach, the display flatness of the tunnel barrier layer 30, i.e., the homogeneity of thickness, can improve, and the homogeneous high tunnel barrier layer 30 of thickness can be formed rather than the tunnel barrier layer 130 by the single oxidizing method. If display flatness is improved, while thin thickness parts will decrease in number to the local target leading to a pinhole, the thickness of an effective tunnel barrier layer will increase. Therefore, a TMR ratio and junction resistance increase. That is, since the danger of pinhole generating decreased, the average of the thickness of the tunnel barrier layer 30 can be lowered, and therefore, junction resistance can be reduced, with the conventional TMR ratio maintained (a S/N ratio can be raised).

[0091] The formation approach of MTJ70 which contains the tunnel barrier layer 30 concerning the gestalt of operation of the 1st of this invention hereafter is explained to a detail with reference to drawing 7 .

[0092] The compound oxidation style which is the gestalt of the 1st operation will be called "an oxidation style I." Drawing 7 is the schematic drawing of the MTJ component 70 containing the tunnel barrier layer 30 formed by the oxidizing method I. After the tunnel barrier layer 30 forms the 1st barrier layer 32 on the ferromagnetic free layer 24, it is oxidized, and it is obtained by [which carried out the laminating further on the 1st barrier layer 32 after oxidizing the 2nd barrier layer 34] carrying out after oxidation treatment. In this oxidation style I, after an oxidation style I forms an aluminum layer on the ferromagnetic free layer 24, it is oxidized, and forms the 1st barrier layer 32 which consists of an aluminum oxide (AlOx), for example so that it can also be called a two-step oxidation style. Then, when it forms on the 1st barrier layer 32 after oxidizing an aluminum layer too and this also oxidizes for example, the 2nd barrier layer 34 is formed. In this case, the two oxidizing-zones, i.e., the 1st, and 2nd barrier layers 32 and 34 form the homogeneous AlOx layer 30 of one **, i.e., a tunnel barrier layer. Then, it is formed on the tunnel barrier layer 30 which a strong magnetic pinned layer 42 turns into from an AlOx layer. Naturally, the 1st and 2nd barrier layers 32 and 34 may be formed by oxidizing other metals and nonmetal layers instead of the above-mentioned aluminum layer. For example, the tunnel barrier layer 30 may also contain at least one sort in the group which consists of chromium, molybdenum, a tantalum, niobium, copper, platinum, palladium, boron, carbon, a tungsten, silicon, titanium, vanadium, a ruthenium, a rhenium, a zirconium, and a gallium. However, as for the tunnel barrier layer 30, it is more desirable that at least one sort in aluminum, a tantalum, nickel, titanium, a hafnium (Hf), magnesium (Mg), silicon, a zirconium, and a gallium is included.

[0093] The oxidation style I which is a two-step oxidation style can be further divided into the following two patterns. That is, it is two, the pattern (it is called the oxidizing method I-1) whose thickness t1 of the 1st barrier layer 32 is less than [of the 2nd barrier layer 34 / thickness t2], and a pattern (it is called an oxidation style I-2) with the thickness t1 of the 1st barrier layer 32 thicker than the thickness t2 of the 2nd barrier layer 34.

[0094] The case where the multilayer tunnel barrier layer 30 whose whole thickness t0 is 0.5nm is formed as an example of an oxidation style I-2 (t1> t2) is explained. First, the laminating of the aluminum film (1st barrier layer 32 before oxidation treatment of t1=0.3nm) with a thickness of 0.3nm is carried out on the 1st ferromagnetic free layer 24 within a chamber by sputtering. The inside of a chamber is exhausted with a pump and the 1st AlOx film (1st barrier layer 32) is formed by exposing the aluminum film (1st barrier layer 32 before oxidation treatment) to pure oxygen or the oxygen plasma after that. Then, thickness carries out the laminating of the 2nd aluminum film (2nd barrier layer 34 before oxidation treatment which is t2=0.2nm) which is 0.2nm on the 1st AlOx film. The inside of a chamber is again exhausted with a pump, and AlOx / "aluminum" film is exposed to pure oxygen or the oxygen plasma, and is oxidized. The high tunnel barrier layer 30 of the display flatness which consists of carrying out like this by the "AlOx/AlOx" film is obtained.

[0095] Although explained in full detail behind, the MTJ component 70 formed by the oxidation style I maintains a TMR ratio, and shows low junction resistance relatively compared with a single oxidation style. As for thickness t1, in the case of an oxidation style I, it is desirable to be 0.6nm or less and for thickness t2 to be less than [thickness t1].

[0096] In addition, in the gestalt of this operation, the laminating of the tunnel barrier layer 30 is carried out on the ferromagnetic free layer 24, and it is [a strong magnetic pinned layer 42] desirable that a laminating is carried out on the tunnel barrier layer 30. Furthermore, as for the thickness of the tunnel barrier layer 30, it is desirable that it is 1.5nm or less.

[0097] Next, while producing MTJ component 70A equipped with tunnel barrier layer 30A by the oxidizing method I-1 so that the thickness (total thickness t0=t1+ t2) of the sum total of the 1st barrier layer 32 before oxidation treatment and the 2nd barrier layer 34 might serve as a predetermined value, by the oxidizing method I-2, MTJ component 70B equipped with tunnel barrier layer 30B was produced, and both property comparison was performed. In addition, evaluation with the same said of MTJ170 by the conventional single oxidation style as an example of a comparison was performed.

[0098] Drawing 8 is the explanatory view showing the relation of the junction resistance R and the total thickness t0

in MTJ component 70B formed by MTJ component 70A and the oxidation style I-2 which were formed by the oxidation style I-1. Here, both used the aluminum film as the 1st barrier layer 32A and 32B before oxidation treatment, and 2nd barrier layer 34A and 34B. The result about the MTJ component 170 equipped with the tunnel barrier layer 130 by the conventional single oxidizing method as an example of a comparison was also shown collectively. In drawing 8 , an axis of ordinate shows a bond resistance R (omega), and the total thickness t0 of the aluminum which is the sum total of the thickness t1 of the 1st barrier layer 32 before oxidation treatment whose axis of abscissa forms tunnel barrier layer 30A, and the thickness t2 of the 2nd barrier layer 34 before oxidation treatment (nm) is shown. In addition, in the tunnel barrier layer 130, it is shown on an axis of abscissa using the aluminum film of a monolayer, using the thickness as t0.

[0099] In drawing 8 , the curve shown by "**" shows the property of the bond resistance R of the MTJ component 170 with the tunnel barrier layer 130 formed by the conventional single oxidizing method. "**" showed what is similarly depended on an oxidation style I-1, and "-" showed what is depended on an oxidation style I-2.

[0100] According to drawing 8 , it is natural, but if thickness t0 decreases, the junction resistance R will decrease. For example, when the monolayer of 0.7nm aluminum is oxidized with a single oxidation style, resistance is 44.5ohms, but when a 0.5nm aluminum monolayer is oxidized, resistance is only 1.4ohms. This inclination is checked also in which oxidation style. However, if the junction resistance R in the same thickness t0 is compared, it changes with oxidation styles. Also in which thickness t0, the lowest junction resistance R is shown, and a single oxidation style shows the high junction resistance R continuously in order of an oxidation style I-2 and an oxidation style I-1.

[0101] Drawing 9 shows the result of having investigated change of a TMR ratio, about the MTJ components 70A and 70B used by drawing 8 . A TMR ratio (%) is shown on an axis of ordinate, and the total thickness t0 of tunnel barrier layer 30A and the aluminum film which is the sum total of the thickness t1 of the 1st barrier layer 32A and 34B before oxidation treatment to carry out and the thickness t2 of the 2nd barrier layer 34A and 34B before oxidation treatment 30B formation (nm) is shown on an axis of abscissa like drawing 8 . It illustrated collectively also about the results of an investigation of the MTJ component 170 by the conventional single oxidation style. In addition, in the tunnel barrier layer 130, it is shown on an axis of abscissa using the aluminum film of a monolayer, using the thickness as t0.

[0102] If thickness t0 decreases from 0.7nm to 0.5nm in the case of the single oxidation style shown by "**" as shown in drawing 9 , according to this, a TMR ratio will decrease from 27% to 5.4%. This means that it is difficult to maintain a high TMR ratio according to the process which forms the tunnel barrier layer 130 of a monolayer by oxidation treatment once, i.e., a single oxidation style, when the thickness of the aluminum layer to which oxidation treatment is performed is thin. If a TMR ratio falls, naturally, the output voltage of a MTJ component or a MTJ head will decline, and, thereby, a S/N ratio will also deteriorate. In addition, the MTJ component used for drawing 8 and drawing 9 has laminated structures, such as "a tantalum (5nm) / NiFe alloy (5nm) / CoFe alloy (2nm) / AlOx(being two-layer or monolayer 0.5-0.7nm)/CoFe alloy (3nm) / PtMn alloy (30nm) / tantalum." Here, the inside of a parenthesis shows the thickness of each class.

[0103] the MTJ component 170 formed with the single oxidation style as shown in drawing 8 and drawing 9 — the total — in the case of thickness t0=0.5nm, 5.4% of TMR ratio and the junction resistance R of 1.3 ohms are shown. MTJ component 70B by the oxidation style I-2 shown by "-" on the other hand — the total — in thickness t0=0.5nm, 14.7% of TMR ratio and the junction resistance R of 9.4 ohms are shown. In this case, tunnel barrier layer 30B was formed by [which oxidized after carrying out the laminating of the thickness t1=0.3nm aluminum film as 1st barrier layer 32B, and carried out the laminating of the thickness t2=0.2nm aluminum film as 2nd barrier layer 34B on this continuously] carrying out after oxidation treatment. Therefore, when forming MTJ component 70B with an oxidation style I-2 and forming especially an aluminum thin layer, both a TMR ratio and the junction resistance R increase. In this result, during the first oxidization, i.e., oxidation treatment of 1st thickness t1=0.3nm barrier layer 32B, although the interface (field which touches the 1st barrier layer 32) of the ferromagnetic free layer 24 under this film oxidizes slightly, a serious problem like the phenomenon which the pinhole produced with the conventional single oxidation style suggests not becoming.

[0104] Table 1 summarizes the result of above-mentioned drawing 8 and drawing 9 in a table.

[0105] O [Table 1]

酸化法	厚みｔ０	平均 Ｒ×Ａ	係数ａ	１×１μｍ²	
	ｎｍ	Ωμｍ²	－	ＴＭＲ （％）	Ｒ （Ω）
酸化法Ｉ－２	３＋２	８．１	１．００５１	１４．７	９．４
酸化法Ｉ－１	３＋３	３７．１	０．９６６２	２５．９	４１．１
酸化法Ｉ－２	４＋２	２３．７	０．９８６９	２６．７	２６．９
酸化法Ｉ－１	３＋４	７８．４	０．９８７４	２５．０	８３．２
酸化法Ｉ－２	４＋３	５２．５	０．９８４４	２６．３	５７．９
単一酸化法	7	４４．５	０．９９２８	２７．６	４５．７
単一酸化法	6	１１．３	１．００５６	１６．９	１３．３
単一酸化法	5	１．４	０．８４９０	５．４	１．３

[0106] In Table 1, the item of a left end train shows the class of oxidation process. the thickness of the aluminum film of the monolayer before oxidation treatment which the item of eye two trains becomes with a tunnel barrier layer in the case of the single oxidizing method -- being shown -- the case of the oxidizing method I -- "-- thickness t1+ of the 1st barrier layer -- thickness t2(both -- aluminum film)" of the 2nd barrier layer is shown. The item of eye three trains shows average RxA (ohmmum2), and the item of eye four trains is a multiplier at the time of fitting [data / the straight line expressed with a linear function]. It is shown that the high quality tunnel barrier layer is formed, so that this multiplier a is close to 1.0. For the item of eye five trains and eye six trains, a plane-of-composition product is 2 1x1 micrometer. The TMR ratio (%) and the junction resistance R (omega) of a case are shown.
[0107] Then, it investigated about the TMR ratio at the time of impressing a magnetic field H to a MTJ component, and the response characteristic of the junction resistance R. Drawing 10 shows the result of MTJ170 equipped with the tunnel barrier layer 130 formed by the conventional single oxidizing method, and, on the other hand, drawing 11 shows the result about MTJ70B equipped with tunnel barrier layer 30B formed by the oxidizing method I-2 in the gestalt of the 1st operation. which tunnel barrier layers 130 and 30B -- also setting -- the total thickness t0 -- 0.5nm and a plane-of-composition product -- 1x1micrometer2 it is . In drawing 10 and 11, an axis of ordinate shows a TMR ratio (%), and an axis of abscissa shows magnetic field H (Oe).
[0108] The tunnel barrier layer 130 was formed by oxidizing the aluminum film with a thickness of 0.5nm independently. As shown in drawing 10 , a big change is not seen to a magnetic field H, but, as for maximum, the junction resistance R remains [the TMR ratio] in about 1.40 (omega) about 5%. On the other hand, tunnel barrier layer 30B was formed according to the process oxidized after carrying out the laminating of the thickness t1=0.3nm aluminum film as 1st barrier layer 32B, and the process which carried out the laminating of the thickness t2=0.2nm aluminum film as 2nd barrier layer 34B continuously and which carries out after oxidation treatment. As shown in drawing 11 , change of bigger responsibility than the single oxidation style of drawing 10 was seen, and, as for maximum, the junction resistance R was set to about 10.7 (omega) by the TMR ratio about 15%.
[0109] drawing 12 -14 -- the total -- they are the TMR ratio which compared each oxidation style at the time of being referred to as thickness t0=0.6nm, and a response curve to the magnetic field H of the junction resistance R. Like drawing 10 and 11, the plane-of-composition product of a tunnel barrier layer unifies, and is 2 1x1 micrometer. It carried out. An axis of ordinate shows a TMR ratio (%) and the junction resistance R (omega), and an axis of abscissa shows magnetic field H (Oe). drawing 12 was formed by the conventional single oxidizing method -- the total -- the response characteristic of the MTJ component 170 equipped with the tunnel barrier layer 130 of the thickness t0=0.6nm aluminum film is shown. Drawing 13 oxidizes the thickness t1=0.4nm aluminum film (1st barrier layer 32B) first, and shows the response characteristic of MTJ component 70B equipped with tunnel (that is, based on oxidizing method I-2) barrier layer 30B formed by next oxidizing the thickness t2=0.2nm aluminum film (2nd barrier layer 34B). Furthermore, drawing 14 oxidizes the thickness t1=0.3nm aluminum film (1st barrier layer 32A) first, and shows the response characteristic of MTJ component 70A equipped with tunnel (that is, based on oxidizing method I-1) barrier layer 30A formed by next oxidizing the thickness t2=0.3nm aluminum film (the 2nd barrier 34A). The response characteristic of a MTJ component changes with oxidation styles as shown in drawing 12 -14.
[0110] drawing 15 -17 [furthermore,] -- the total -- they are the TMR ratio which compared each oxidation style in thickness t0=0.7nm, and a response curve to the magnetic field H of the junction resistance R. the plane-of-composition product of each tunnel barrier layer -- 1x1micrometer2 it is -- an axis of ordinate shows a TMR ratio (%) and the junction resistance R (omega), and an axis of abscissa shows magnetic field H (Oe). Drawing 15 shows the response characteristic of the MTJ component 170 by the single oxidation style. Drawing 16 shows the response characteristic in MTJ70B containing tunnel (that is, based on oxidizing method I-2) barrier layer 30B using the thickness t2=0.3nm aluminum film as 2nd barrier layer 34B before oxidation treatment, using the thickness t1=0.4nm aluminum film as 1st barrier layer 32B before oxidation treatment. Furthermore, drawing 17 shows the response characteristic in MTJ70A containing tunnel (that is, based on oxidizing method I-1) barrier layer 30A using the thickness t2=0.4nm aluminum film as 2nd barrier layer 34A before oxidation treatment, using the thickness t1=0.3nm aluminum film as 1st barrier layer 32A before oxidation treatment. As shown in drawing 15 -17, when it is referred to as t0=0.7nm, the difference by the oxidation style is accepted about the response characteristic over a magnetic field H.
[0111] The difference by the single oxidation style, the oxidation style I-1, and the oxidation style I-2 appeared in the response characteristic of the TMR ratio to a magnetic field H, and the junction resistance R as described above. For example, when drawing 16 and drawing 17 are referred to and it has the thickness not more than thickness t2 of the 2nd barrier layer 34 before the thickness t1 of the 1st barrier layer 32 before oxidation treatment oxidizing, in the case of the oxidation style I-1 (t1 <=t2), the MTJ component 70 shows the bigger bond resistance R than the case of an oxidation style I-2 (t1> t2). The aluminum film (2nd barrier layer 34 before oxidation treatment) with which this was formed on the AlOx film (1st barrier layer 32) has crystal growth better than the case where it is directly formed on a ferromagnetic layer, and means that can obtain the film without far-reaching micropore, consequently the 2nd AlOx film (2nd barrier layer 34) with very few pinholes is formed.
[0112] Drawing 18 is the explanatory view showing the result of having investigated the relation between a sense current and bias voltage in the MTJ component 70 equipped with the tunnel barrier layer 30 which consists of AlOx of the MTJ component 170 equipped with the tunnel barrier layer 130 which consists of AlOx by the conventional single oxidizing method, and the two-layer structure by the method I of oxidizing the gestalt of the 1st operation. An axis of ordinate shows a sense current (A), and an axis of abscissa shows bias voltage (V). In this investigation, from

the up electrical-and-electric-equipment lead 60, the direction impressed to the lower electrical-and-electric-equipment lead 10 was made into positive bias, and it displayed by "**" or "-" in the explanatory view. On the other hand, from the lower electrical-and-electric-equipment lead 10, the direction impressed to the up electrical-and-electric-equipment lead 60 was made into negative bias, and it displayed by "**" or "O" in the explanatory view. According to drawing 18 , the MTJ component 170 by the single oxidation style displayed by "**" and "**" shows that the response characteristic excellent in the direction of the MTJ component 70 by the oxidation style I displayed by "-" and "O" is acquired. That is, in the tunnel barrier layer formed by dividing oxidation treatment into multiple times and performing it, it does not depend in the direction of bias, but a more symmetrical sense current-bias voltage curve is obtained.

[0113] Drawing 19 is the schematic drawing showing the profile of the obstruction height of the tunnel barrier layer 130 formed by the conventional single oxidizing method. As shown in drawing 19 , the profile of the obstruction height by the single oxidation style is unsymmetrical, and a top face differs in obstruction height greatly from a base. That is, the obstruction height phi 2 on top is more remarkably [than the obstruction height phi 1 at the bottom] larger. In the MTJ component 170 interior, the top face of the tunnel barrier layer 130 touched the strong magnetic pinned layer 142, and the base is in contact with the ferromagnetic free layer 124. The cause by which the profile of obstruction height becomes unsymmetrical is related to especially the soft oxidation approach like natural oxidation. Since the top face of the tunnel barrier layer 130 will contact oxygen gas more directly when it is exposed to an oxygen ambient atmosphere, its oxygen atom distributed near the tunnel barrier layer top face increases in number. On the other hand, there are few oxygen atoms distributed near the base, and they do not fully oxidize. According to such a cause, as shown in drawing 19 , the asymmetry of an obstruction height profile arises.

[0114] On the other hand, drawing 20 is the schematic drawing showing the profile of the obstruction height of the tunnel barrier layer 30 formed by the method I of oxidizing the gestalt of this operation. As shown in drawing 20 , the profile of the obstruction height by the oxidation style I has good symmetric property, and its difference of the obstruction height phi 2 on top and the obstruction height phi 1 at the bottom is smaller than the profile by the single oxidation style of drawing 18 . Namely, according to the approach of carrying out additional formation of the 2nd aluminum oxide film (2nd barrier layer 34), after forming the 1st aluminum oxide film (1st barrier layer 32) While a thin (the thickness before oxidation treatment (for example, the thickness of the aluminum film)) part and the annealing treatment by heating advance, an oxygen atom can carry out internal diffusion, oxidation treatment progresses near the base, and, therefore, the symmetric property of an obstruction height profile is improved.

[0115] <the effectiveness in the gestalt of the 1st operation> -- as mentioned above, since the tunnel barrier layer was formed with the application of two steps of oxidization processes according to the gestalt of this operation, compared with the conventional method of oxidizing at once, the tunnel barrier layer 30 which has uniform insulation according to the thickness direction can be formed. Therefore, the danger of pinhole generating is reduced and the MTJ component 70 equipped with the thinner tunnel barrier layer 30 can be offered.

[0116] furthermore, the tunnel barrier layer 30 which has uniform insulation according to the thickness direction compared with the conventional method of oxidizing at once according to the gestalt of this operation — formation — since things are made, the difference of the obstruction height phi 2 in the base of the tunnel barrier layer 30 and the obstruction height phi 1 in a top face can be made small. That is, the thickness direction symmetry of the more excellent obstruction height is acquired, and, for this reason, it is not influenced in the direction of bias, but it becomes possible to obtain the MTJ component 70 used as the almost same sense current-bias voltage curve.

[0117] [The gestalt of the 2nd operation], next the gestalt of operation of the 2nd of this invention are explained.

[0118] As mentioned above, the gestalt of the 1st operation divides the formation process of a tunnel barrier layer into two steps, repeats the procedure of membrane formation and oxidation treatment of a metal membrane or the nonmetal film twice, and is made to perform it. On the other hand, at the point which divides the formation process of a tunnel barrier layer into two steps, although the gestalt of this operation is the same, after it forms a ferromagnetic layer on the 2nd barrier layer rather than oxidizes the 2nd barrier layer which is a metal membrane or the nonmetal film in an oxygen ambient atmosphere, it is made to carry out oxidation treatment of the 2nd barrier layer by diffusing the oxygen atom which exists in the interior.

[0119] Hereafter, with reference to drawing 21 -28, the magnetic tunnel junction component, its manufacture approach, the magnetic tunnel junction mold head, and its manufacture approach of a gestalt of this operation are explained. Here, it supposes that only a different description part from the gestalt of the above-mentioned implementation is explained, in addition explanation is suitably omitted about the same part. Similarly, also in drawing 21 -28, about the same part, the same sign is substantially attached with the component of the gestalt (drawing 2 -20) of implementation of the above 1st, and explanation is omitted suitably.

[0120] <Configuration of MTJ component> drawing 21 and drawing 22 are the outline sectional views of MTJ section 70C and 70C' formed by the oxidation style II concerning the gestalt of this operation. Drawing 21 shows MTJ component 70C equipped with the strong magnetic pinned layer 42 on the tunnel barrier layer 31, and drawing 22 shows MTJ section 70C' which equipped the bottom of tunnel barrier layer 31' with strong magnetic pinned layer 42'. ** which gives the same sign to the same component as drawing 4 and drawing 5 in drawing 21 and drawing 22 . As shown in drawing 21 , in MTJ component 70C, the seed layer 22, the ferromagnetic free layer 24, the tunnel barrier layer 31, the strong magnetic pinned layer 42, the antiferromagnetism layer 44, and the protective layer 46 have structure by which the laminating was carried out to this order. The tunnel barrier layer 31 is divided into two more layers, the 1st barrier layer 35 is formed so that the ferromagnetic free layer 24 may be touched, and the 2nd barrier layer 36 is formed on it. On the other hand, MTJ component 70C' which is the modification of MTJ

component 70C has the structure where the laminating of seed layer 22', the template layer 25, antiferromagnetism layer 44' strong magnetic pinned layer 42' tunnel barrier layer 31', ferromagnetic free layer 24', and protective layer 46' was carried out to this order, as shown in drawing 22 . Too, tunnel barrier layer 31' is formed from two layers. The 1st barrier layer 37 is formed so that strong magnetic pinned layer 42' may be touched, and the 2nd barrier layer 38 is formed on it. In addition, substantially, since the MTJ head equipped with these MTJ(s) component 70C and 70C' is equivalent, it abbreviates explanation to the gestalt of the 1st operation.

[0121] The manufacture approach of MTJ component 70C by the <manufacture approach of a MTJ component>, then the oxidation style II concerning the gestalt of this operation and 70C' is explained below with reference to drawing 21 and drawing 22 . In an oxidation style II, like an oxidation style I, after carrying out the laminating of a metal membrane or the nonmetal film, the 1st barrier layer 35 and 37 is obtained by oxidizing. The structure (drawing 21) where the tunnel barrier layer 31 is fixed on the ferromagnetic free layer 24 is more desirable. Next, a laminating is carried out on the 1st barrier layer 35 and 37 after oxidizing the 2nd barrier layer 36 and 38 which is a metal membrane or the nonmetal film. As for especially the thickness of the 2nd barrier layer 36 and 38, it is desirable that it is the range of 0.1-0.4nm 0.4nm or less. As for the 1st barrier layer 35 and 37 and the 2nd barrier layer 36 and 38, it is desirable that at least one of aluminum, a tantalum, nickel, titanium, a hafnium, magnesium, silicon, a zirconium, and galliums is included.

[0122] Next, the laminating of the up electrode layered product 40 and 40' is carried out on the 2nd barrier layer 36 and 38. Besides, annealing treatment of the section electrode layered product 40 and 40' is preferably carried out at the temperature of less than 300 degrees C, and the 2nd barrier layer 36 and 38 on the 1st barrier layer 35 and 37 oxidizes by the internal diffusion of oxygen. In this case, since the 2nd barrier layer 36 and 38 is not heated under an oxygen ambient atmosphere, most oxidizes freely. How to carry out the laminating of other barrier layers, and oxidize in front of a protective layer 46 and the laminating of 46', as other approaches, is also considered. In this case, the 1st barrier layer 35 and 37 before oxidation treatment has the thickness more than the thickness of other barrier layers by which a laminating is carried out on them.

[0123] <Evaluation of tunnel barrier layer> drawing 23 is the explanatory view showing the result of having compared the TMR ratio, about the MTJ component 170 by the conventional single oxidation style, and MTJ component 70C by the oxidation style II. An axis of ordinate shows a TMR ratio, the upper axis of abscissa shows the thickness t4 of the 2nd barrier layer 36 before added oxidation treatment, and a lower axis of abscissa shows the total thickness t10 showing the sum total of the thickness t3 of the 1st barrier layer 35 before oxidation treatment, and the thickness t4 of the 2nd barrier layer 36 further. In addition, the aluminum film was used for the 1st and 2nd barrier layers 35 and 36. As shown in drawing 23 , when the total thickness t10 increases to 1nm from 0.7nm in the case of the conventional single oxidation style, a TMR ratio shows a linear reduction. On the other hand, in case the total thickness t10 changes to 0.9nm from 0.8nm in the case of an oxidation style II, a TMR ratio decreases greatly.

[0124] Drawing 24 shows the result of having compared change of the product (following, RxA) of junction resistance and a plane-of-composition product, about the MTJ components 170 and 70C evaluated by drawing 23 . An axis of ordinate shows RxA (ohmmum2), the thickness t4 of the 2nd barrier layer 36 before oxidation treatment to which the upper axis of abscissa was added is shown, and the total thickness t10 which expresses the sum total of the thickness t3 of the 1st barrier layer 35 before a lower axis of abscissa oxidizing and the thickness t4 of the 2nd barrier layer 36 further is shown. As shown in drawing 24 , when being based on an oxidation style II, RxA smaller than a single oxidation style is shown. If the total thickness t10 increases from 0.9nm to 1.0nm according to the single oxidation style, junction resistance will increase greatly. In an oxidation style II, RxA smaller than a single oxidation style is obtained in the range at least whose total thickness t10 is 0.7-1.0nm. Therefore, when the total thickness t10 is the same, MTJ component 70C which inserted the 2nd very thin barrier layer 36, and was formed shows a TMR ratio comparable as the MTJ component 170 by the single oxidation style, and shows RxA smaller than it.

[0125] As shown in drawing 24 , the increment in RxA means that the 2nd barrier layer 36 has oxidized. However, although the oxidation style II by this internal diffusion is very loose oxidization compared with the conventional single oxidation style, since the oxygen content is restricted, RxA of the tunnel barrier layer 31 formed by the oxidizing method II becomes smaller than a single oxidation style. The above-mentioned description in the oxidizing method II by internal diffusion leads to a sharp reduction of the TMR ratio of the 2nd barrier layer 36 inserted on the 1st barrier layer 35 also with regards to metal atoms, such as aluminum, remaining in the interface of the tunnel barrier layer 31 and a ferromagnetic layer.

[0126] After carrying out annealing treatment of drawing 25 at 250 degrees C for 5 hours, it is the explanatory view showing the sense current-bias voltage curve in MTJ component 70C equipped with the tunnel barrier layer 31 formed by the oxidizing method II. An axis of ordinate shows a sense current (mA), and an axis of abscissa shows bias voltage (V). Here, thickness t3 was fixed to 0.7nm, and it changed 0.1nm of thickness t4 at a time from 0.0nm to 0.4nm. As shown in drawing 25 , it turns out by thickening thickness t4 that the symmetric property of the tunnel barrier layer 31 is improved. That is, it follows on the thickness t4 of the 2nd aluminum film (2nd barrier layer 36 before oxidation treatment) increasing from 0, and the difference by the direction of bias is small. Thickness t4 means that, as for saying [0], the 2nd barrier layer 36 does not exist here. As for annealing treatment, it is desirable to be carried out in 300 degrees C or more and 5 hours or less.

[0127] Drawing 26 is the schematic drawing showing the profile of the obstruction height of the tunnel barrier layer 130 formed by the conventional single oxidizing method. On the other hand, drawing 27 is the schematic drawing showing the profile of the obstruction height of the tunnel barrier layer 31 formed by the oxidizing method II by the

gestalt of this operation. As shown in drawing 26 , the profile of a single oxidation style is unsymmetrical and the obstruction height phi 2 on top is remarkably large from the obstruction height phi 1 at the bottom. As shown in drawing 27 on the other hand, the profile of an oxidation style II has the difference of the obstruction height phi 2 on top and the obstruction height phi 1 at the bottom smaller than the profile of a single oxidation style. Like the gestalt of the 1st operation, this result is based on the effectiveness of the internal diffusion of the oxygen in the tunnel barrier layer 31, and is a symmetric-property improvement and match of a sense current-bias voltage curve.

[0128] Drawing 28 is a resistance difference [as opposed to / layer / which was formed by the single oxidizing method, the oxidizing method I, and the oxidizing method II / tunnel barrier / bias voltage] [abs(R+-R-)/] (R++R-). It is the explanatory view showing change. Here, it is R+. The junction resistance of the tunnel barrier layer to bias voltage is shown, and it is R. - The junction resistance of the tunnel barrier layer to the bias voltage of the opposite direction is shown. An axis of ordinate shows a resistance difference (%), and an axis of abscissa shows bias voltage (V). The display of "**" shows the result of the tunnel barrier layer 130 by the conventional single oxidizing method. The display of "<>, O, **, -" shows the result of the tunnel barrier layer 31 which added the 2nd aluminum film (2nd barrier layer 36 before oxidation treatment) of the thickness which changes with oxidizing methods II. "**" is a result about the tunnel barrier layer 30 formed by the oxidizing method I. As shown in drawing 28 , in the case of the oxidizing methods I and II, compared with the single oxidizing method, the resistance difference over bias voltage is remarkably low. This shows that the profile symmetric property of the obstruction height of the tunnel barrier layers 30 and 31 in the MTJ components 70 and 70C formed by the oxidizing methods I and II has been improved. In this case, the bias voltage range of a tunnel barrier layer is 0-500mV, and it is the resistance difference [abs(R+-R-)/] (R++R-) of the bias voltage of positive/negative. It is desirable to be formed so that it may be less than 3%.

[0129] <the effectiveness in the gestalt of the 2nd operation> -- as mentioned above according to the gestalt of this operation Since it was made to perform oxidation treatment of the 2nd barrier layer 36 and 38 by diffusing the oxygen which divides the formation process of a tunnel barrier layer into two steps, and is contained in the 1st barrier layer 35 and 37 Compared with the gestalt of the 1st operation, the difference of the obstruction height phi 2 in the base of a tunnel barrier layer and the obstruction height phi 1 in a top face can be made smaller. That is, it becomes possible to obtain the MTJ component used as the almost same sense current-bias voltage curve which the thickness direction symmetry of obstruction height improves further, and is not influenced in the direction of bias.

[0130] In order to carry out an additional indication for various gestalten of this invention, the following reference is mentioned as bibliography.

[0131] The United States patent application by Olivier Redon and others for whom it applied with the reference on July 20, 2000 "Magnetic Tunnel Junction Read Head Using Hybrid and Low Magnetization Flux Guide (they are the specification of the magnetic tunnel junction reproducing head" (it corresponds to 192 and No. 320 the 60th/of the U.S. temporary application for which it applied on March 27, 2000) using a hybrid low magnetization flux guide, and its drawing.) This invention aims at the design of the reproducing head which makes a TMR ratio max by choosing the ingredient equipped with the greatest spin polarization. In this reproducing head, the effectiveness of a flux guide can be raised to the maximum using a hybrid low magnetization ingredient, and a big signal output can be attained.

[0132] As mentioned above, although the gestalt of each above-mentioned operation was mentioned and this invention was explained, this invention is not limited to the gestalt of the above-mentioned implementation, but is variously deformable. For example, although formed with the gestalt of this operation by oxidizing the film which contains aluminum for a tunnel barrier layer, it is not limited to this. Moreover, although the tunnel barrier layer was divided and formed in two steps with the gestalt of this operation, it subdivides further, and the 3rd barrier film and the barrier film beyond it can be added, a multistage story can be oxidized, and a more homogeneous tunnel barrier layer can also be generated. In this case, as for the barrier film added, it is desirable to make it become thin gradually.

[0133]

[Effect of the Invention] As explained above, according to the manufacture approach of a magnetic tunnel junction component given in any 1 term of a magnetic tunnel junction component given in any 1 term of claim 1 thru/or claim 13 and claim 14 thru/or claim 38 Since it was made for a tunnel barrier layer to contain the 1st barrier layer by which it was oxidized, and the 2nd barrier layer, compared with the conventional tunnel barrier layer containing the single barrier layer in which it was oxidized, the tunnel barrier layer which has uniform insulation according to the thickness direction can be obtained. Therefore, while being able to improve the symmetric property of an electrical property and raising ESD and a TDDB property, a TMR ratio can be raised, maintaining a low bond resistance under a room temperature. Therefore, in the equipment of a hard disk drive or others, it can apply to binary data playback of a high density magnetic-recording medium, and, of course, other magnetic field detection devices can be further applied also to other devices and environments of the same kind. Furthermore, a percent defective can be reduced and efficient mass production method is attained.

[0134] According to the manufacture approach of a magnetic tunnel junction mold head according to claim 39, claim 40, and a magnetic tunnel junction mold head according to claim 41 Since it was made for the tunnel barrier layer of a magnetic tunnel junction component to contain the 1st barrier layer by which it was oxidized, and the 2nd barrier layer Compared with the conventional tunnel barrier layer containing the single barrier layer in which it was oxidized, the magnetic tunnel junction mold head equipped with the tunnel barrier layer which has uniform insulation according to the thickness direction can be obtained. Therefore, while having the electrical property excellent in symmetric property and having high performance characteristics also to ESD and TDDB, the reproducing head which shows a

low bond resistance and a high TMR ratio under a room temperature is obtained. This magnetic tunnel junction mold head is applicable to binary data playback of the high density magnetic-recording medium of a hard disk drive or others. Furthermore, a percent defective can be reduced and efficient mass production method is attained.

[Translation done.]

* NOTICES *

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damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the top view of the MTJ head concerning the gestalt of operation of the 1st of this invention.
[Drawing 2] It is the fragmentary sectional view of the MTJ head of drawing 1 .
[Drawing 3] The sectional view in the modification of the MTJ head concerning the gestalt of operation of the 1st of this invention is shown.
[Drawing 4] It is the sectional view of the MTJ component in the MTJ head concerning the gestalt of operation of the 1st of this invention shown in drawing 2 .
[Drawing 5] It is the sectional view of the MTJ component in the MTJ head concerning the gestalt of operation of the 2nd of this invention shown in drawing 3 .
[Drawing 6] It is the sectional view of the tunnel barrier layer formed by the conventional single oxidizing method.
[Drawing 7] It is the sectional view of the tunnel barrier layer formed by the oxidizing method I concerning the gestalt of operation of the 1st of this invention.
[Drawing 8] It is the property Fig. showing the thickness dependency of the tunnel barrier layer of the junction resistance in the MTJ component concerning the gestalt of operation of the 1st of this invention.
[Drawing 9] It is the property Fig. showing the thickness dependency of the tunnel barrier layer of the TMR ratio in the MTJ component concerning the gestalt of operation of the 1st of this invention.
[Drawing 10] It is a response curve to the magnetic field of the TMR ratio in the MTJ component equipped with the tunnel barrier layer with a thickness of 0.5nm by the conventional single oxidizing method, and junction resistance.
[Drawing 11] It is a response curve to the magnetic field of the TMR ratio in the MTJ component equipped with the tunnel barrier layer with a thickness of 0.5nm by the oxidizing method I-2 concerning the gestalt of operation of the 1st of this invention, and junction resistance.
[Drawing 12] It is a response curve to the magnetic field of the TMR ratio in the MTJ component equipped with the tunnel barrier layer with a thickness of 0.6nm by the conventional single oxidizing method, and junction resistance.
[Drawing 13] It is a response curve to the magnetic field of the TMR ratio in the MTJ component equipped with the tunnel barrier layer with a thickness of 0.6nm by the oxidizing method I-2 concerning the gestalt of operation of the 1st of this invention, and junction resistance.
[Drawing 14] It is a response curve to the magnetic field of the TMR ratio in the MTJ component equipped with the tunnel barrier layer with a thickness of 0.6nm by the oxidizing method I-1 concerning the gestalt of operation of the 1st of this invention, and junction resistance.
[Drawing 15] It is a response curve to the magnetic field of the TMR ratio in the MTJ component equipped with the tunnel barrier layer with a thickness of 0.7nm by the conventional single oxidizing method, and junction resistance.
[Drawing 16] It is a response curve to the magnetic field of the TMR ratio in the MTJ component equipped with the tunnel barrier layer with a thickness of 0.7nm by the oxidizing method I-2 concerning the gestalt of operation of the 1st of this invention, and junction resistance.
[Drawing 17] It is a response curve to the magnetic field of the TMR ratio in the MTJ component equipped with the tunnel barrier layer with a thickness of 0.7nm by the oxidizing method I-1 concerning the gestalt of operation of the 1st of this invention, and junction resistance.
[Drawing 18] It is the property Fig. showing the bias voltage-sense current characteristic in the MTJ component equipped with the tunnel barrier layer formed by the oxidizing method I concerning the conventional single oxidizing method and the gestalt of operation of the 1st of this invention.
[Drawing 19] It is the schematic diagram showing the profile of the obstruction height of the tunnel barrier layer formed by the conventional single oxidizing method.
[Drawing 20] It is the schematic diagram showing the profile of the obstruction height of the tunnel barrier layer formed by the oxidizing method I concerning the gestalt of operation of the 1st of this invention.
[Drawing 21] It is the sectional view of the MTJ component equipped with the strong magnetic pinned layer on the tunnel barrier layer formed by the oxidizing method II concerning the gestalt of operation of the 2nd of this invention.
[Drawing 22] It is the sectional view of the MTJ component which equipped with the strong magnetic pinned layer the bottom of the tunnel barrier layer formed by the oxidizing method II concerning the gestalt of operation of the 2nd of this invention.
[Drawing 23] It is the property Fig. showing the TMR ratio to the thickness of the aluminum layer in the MTJ component containing the tunnel barrier layer formed by the oxidizing method II concerning the gestalt of operation

of the 2nd of this invention.
[Drawing 24] It is the property Fig. showing the junction resistance over the thickness of the aluminum layer in the MTJ component containing the tunnel barrier layer formed by the oxidizing method II concerning the gestalt of operation of the 2nd of this invention.
[Drawing 25] It is the property Fig. showing the bias voltage-sense current characteristic of the MTJ component by the oxidizing method II concerning the gestalt of operation of the 2nd of this invention.
[Drawing 26] It is the schematic diagram showing the profile of the obstruction height of the tunnel barrier layer formed by the conventional single oxidizing method.
[Drawing 27] It is the schematic diagram showing the profile of the obstruction height of the tunnel barrier layer formed by the oxidizing method II concerning the gestalt of operation of the 2nd of this invention.
[Drawing 28] In the MTJ component containing the tunnel barrier layer formed by the oxidizing methods I and II concerning the gestalt of the 1st and operation of the 2nd of the conventional oxidation style and this invention, it is the property Fig. showing the resistance difference over bias voltage.
[Description of Notations]
1 [— Lower electrode layered product,] — A MTJ head, 9 -- A substrate, 10 — A lower electrical-and-electric-equipment lead, 20 22 [— Tunnel barrier layer,] -- A seed layer, 23 — The magnetization direction, 24 — 30 A ferromagnetic free layer, 31 32, 35, 37 [— A strong magnetic pinned layer, 44 / — An antiferromagnetism layer 46 / — A protective layer, 50 / — An insulator, 60 / — An up electrical-and-electric-equipment lead, 70 / — MTJ component] — The 1st barrier layer, 34, 36, 38 — The 2nd barrier layer, 40 — An up electrode layered product, 42

[Translation done.]